

Supporting information

1. Unit costs analysis

Calculating simple unit costs for companies can improve our understanding of cost trends and can provide indications of differences between companies. However, because the choice of denominator in the unit cost comparisons is important, we present two different unit cost measures in this document. These are unit costs per property billed and volumetric unit costs. One reason for the different rankings of companies between these two measures is the impact of significantly large users who only receive one bill, but receive a large volume of water. This highlights the importance of not relying too heavily on unit cost comparisons.

1.1 Unit costs breakdown

As well as presenting the total unit cost to customers for each water company, we also break down the costs into:

- the cost of operations;
- capital maintenance charges; and
- the return on capital.

Cost of operations

This is the cost of running the day-to-day business. It includes energy, employment and material costs, but excludes the costs of providing third party services. It also excludes atypical and exceptional costs, such as restructuring costs. These are unusual one-off costs that are not part of the continuing operation of the business.

Capital maintenance charges

Each company is required to maintain the operating capability of its asset systems to ensure continuity of service for current and future consumers. We call this serviceability. For above-ground assets each company applies a current cost depreciation charge based on the expected life of these assets. For underground assets, each company applies an infrastructure renewals charge. This reflects the expected costs, averaged over a suitable time period, of maintaining the serviceability to customers of these long-lived assets. The charges recorded in the accounts may differ from the costs of maintenance actually incurred in any year. This is why, when we assess relative capital maintenance efficiency, we use the actual costs recorded in the accounts, averaged over a period of time.

Other factors that may affect the unit costs of capital maintenance include:

- the quantity of inherited assets;
- the age and performance of inherited assets;
- differences in accounting practices between companies; and
- previous management decisions on the balance between capital and operating expenditure.

Return on capital

This represents the remuneration to the providers of capital, both equity shareholders and lenders. It is the difference between income and costs (both operating costs and capital maintenance charges). In this analysis, we have included unusual one-off operating costs, called atypical and exceptional expenditure, in the return on capital to avoid distorting unit operating cost comparisons.

Differences in the return on capital reflect differences in the cost of capital and the capital base of each company. The return on capital is influenced by gains from increased efficiency and the timing of previous capital expenditure. The return may also reflect the requirement for internal funds to finance future investments.

1.2 Unit cost comparisons

The tables below show the breakdown of volumetric unit costs for the water and sewerage services for 2006-07, ranked in ascending order of cost to customers, on a pence per cubic metre (p/m³) basis. The tables on pages 5 and 6 show the breakdown of unit costs for each household and non-household billed for 2006-07 on a pounds per property (£/property) basis.

Water delivered unit costs 2006-07

Company	Cost to customers (p/m ³)	Breakdown		
		Cost of operations (p/m ³)	Cost of capital maintenance (p/m ³)	Return on capital (p/m ³)
Portsmouth	54	30	13	11
Bournemouth & W Hampshire	62	28	19	15
South Staffordshire	72	36	19	17
Three Valleys	77	37	22	18
Cambridge	78	40	18	19
Southern	81	35	34	12
Northumbrian	82	37	20	24
Dee Valley	83	44	27	12
Mid Kent	91	38	26	26
South East	93	41	25	28
Thames	93	43	25	26
Sutton & East Surrey	93	45	30	18
Yorkshire	94	33	27	33
Bristol	94	45	31	18
Severn Trent	97	39	30	28
Anglian	101	35	26	40
United Utilities	104	38	31	35
Wessex	106	35	33	38
Dŵr Cymru	106	44	42	20
South West	114	45	31	37
Folkestone & Dover	116	55	26	34
Tendring Hundred	151	61	36	54
Industry (weighted) average	94	39	28	28

Key:	Below 70	Below 30	Below 20	Below 20
	70-79	30-34	20-24	20-24
	80-89	35-39	25-29	25-29
	90-99	40-44	30-34	30-34
	Above 99	Above 44	Above 34	Above 34

Note:

Numbers may not add because of rounding.

Sewage collected unit costs 2006-07

Company	Cost to customers (p/m ³)	Breakdown		
		Cost of operations (p/m ³)	Cost of capital maintenance (p/m ³)	Return on capital (p/m ³)
Thames	66	27	23	16
Severn Trent	116	40	33	43
Yorkshire	119	39	37	43
Northumbrian	128	42	38	47
Wessex	129	37	36	56
Dŵr Cymru	147	51	40	56
Anglian	148	51	50	47
Southern	153	43	51	59
United Utilities	158	49	49	60
South West	239	76	76	87
Industry (weighted) average	119	40	38	42
Key:	Below 100	Below 35	Below 30	Below 35
	100-119	35-39	30-34	35-44
	120-139	40-44	35-39	45-54
	140-159	45-49	40-44	55-64
	Above 159	Above 49	Above 44	Above 64

Note:

Numbers may not add because of rounding.

Water service unit cost per property billed 2006-07

Company	Cost to customers (£/property)	Breakdown		
		Cost of operations (£/property)	Cost of capital maintenance (£/property)	Return on capital (£/property)
Portsmouth	106	59	26	22
South Staffordshire	136	68	37	31
Southern	144	62	61	22
Cambridge	146	76	33	37
Dee Valley	161	85	53	23
Bournemouth & W Hampshire	162	73	50	39
Northumbrian	165	75	41	49
Bristol	169	80	56	33
Three Valleys	171	81	49	41
Severn Trent	172	69	52	50
Sutton & East Surrey	174	85	56	34
Yorkshire	177	63	52	62
Mid Kent	181	76	53	52
South East	181	79	49	54
Anglian	187	65	49	74
United Utilities	192	71	57	65
Tendring Hundred	198	80	47	71
Dŵr Cymru	200	83	80	37
Thames	205	94	54	57
South West	214	85	59	70
Wessex	216	71	68	77
Folkestone & Dover	220	106	50	65
Industry (weighted) average	182	75	53	53

Key:	Below 150	Below 65	Below 40	Below 30
	150-164	65-69	40-44	30-39
	165-179	70-74	45-49	40-49
	180-194	75-79	50-54	50-59
	Above 194	Above 79	Above 54	Above 59

Note:

Numbers may not add because of rounding.

Sewerage service unit costs per property billed 2006-07

Company	Cost to customers (£/property)	Breakdown		
		Cost of operations (£/property)	Cost of capital maintenance (£/property)	Return on capital (£/property)
Thames	128	52	45	31
Severn Trent	181	62	52	67
Yorkshire	187	61	58	67
Anglian	210	73	71	66
Wessex	213	62	59	92
Northumbrian	214	71	64	79
Dŵr Cymru	230	80	62	88
Southern	237	66	79	92
United Utilities	252	78	78	95
South West	324	103	103	118
Industry (weighted) average	196	66	62	69
Key:	Below 160	Below 45	Below 40	Below 55
	160-179	45-54	40-49	55-64
	180-199	55-64	50-59	65-74
	200-219	65-74	60-69	75-84
	Above 219	Above 74	Above 69	Above 84

Note:

Numbers may not add because of rounding.

1.3 Unit cost methodology

We use publicly available data from the June returns to calculate the unit costs presented here. The data can be found on our website. The figures below explain our methodology for calculating the unit costs.

Calculating water unit costs

Calculation			JR table	BON ref.
Cost of operations	=	Total operating expenditure	21	BM351
	–	Third party services (operating expenditure)	21	BM323
	–	Exceptional operational expenditure	21	BM319
	–	Atypicals	n/a ¹	n/a ¹
Cost of capital maintenance	=	Total capital maintenance	21	BM350
	–	Third party services (current cost depreciation)	21	BM334
	–	Third party services (infrastructure renewals charge)	21	BM335
Cost of return on capital	=	Income	n/a	n/a
	–	Cost of operations	n/a	n/a
	–	Cost of capital maintenance	n/a	n/a
where income	=	Total turnover (water service)	23	BO1181
	+	Current cost profit or loss on sale of fixed assets (water service)	23	BO2992
	+	Working capital adjustment (water service)	23	BO3000
	–	Exceptional income (water service)	23	BR940
	–	Third party services (water service)	23	BO1194
Water delivered	=	Water delivered (potable)	10	BN2330
Properties billed	=	Households billed water	7	BN2120
	+	Non-households billed water	7	BN2215

Note:

1. Atypicals are reported in June return commentaries to table 21.

Calculating sewerage unit costs

Calculation			JR table	BON ref.
Cost of operations	=	Total operating expenditure	22	BM850
	–	Third party services (operating expenditure)	22	BM823
	–	Exceptional expenditure	22	BM819
	–	Atypicals	n/a ¹	n/a ¹
Cost of capital maintenance	=	Total capital maintenance	22	BM849
	–	Third party services (current cost depreciation)	22	BM823
	–	Third party services (infrastructure renewals charge)	22	BM819
Cost of return on capital	=	Income	n/a	n/a
	–	Cost of operations	n/a	n/a
	–	Cost of capital maintenance	n/a	n/a
where income	=	Total turnover (sewerage service)	23	BO1182
	+	Current cost profit or loss on sale of fixed assets (sewerage service)	23	BO2994
	+	Working capital adjustment (sewerage service)	23	BO3050
	–	Exceptional income (sewerage service)	23	BR945
	–	Third party services (sewerage service)	23	BO1195
Sewage collected	=	Volume wastewater returned	14	BN2430
Properties billed	=	Households billed sewage	13	BN2150
	+	Non-households billed sewage	13	BN2270

Note:

1. Atypicals are reported in June return commentaries to table 22.

2. Relative efficiency methodology

We assess the relative efficiency of the water and sewerage companies to allow us to set price limits for this monopoly industry. In the absence of a competitive market, we also use comparative competition to drive the companies to become more efficient. We monitor and publish the companies' progress each year. At each price review, we use our assessments to derive efficiency factors to include in price limits and to identify which companies qualify for enhanced future incentives.

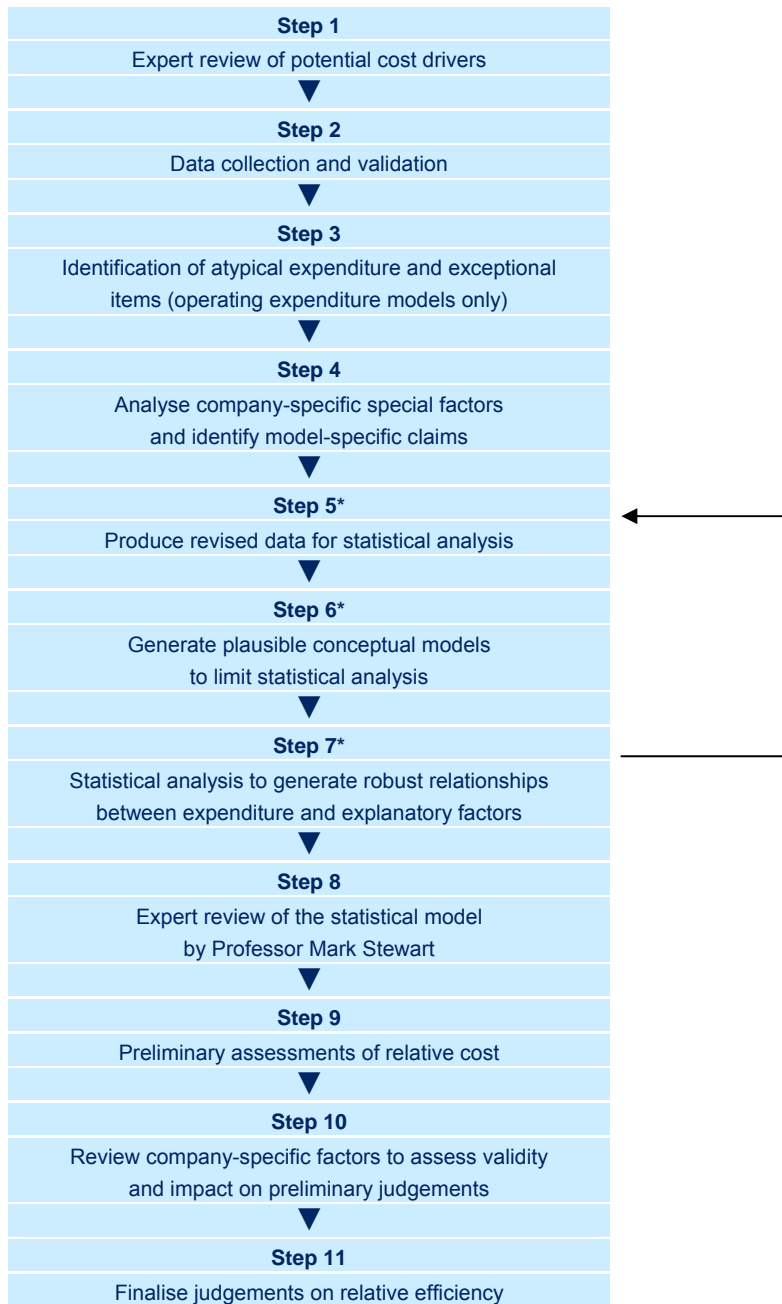
In October, we published our [methodology paper](#), which set out our proposals for setting price limits for 2010-15. In this document, we set out our preferred approach to incentives and efficiency for both operating expenditure and capital maintenance expenditure. For operating expenditure, we propose to evolve the approach we used at the 2004 price review (PR04), which is described below. For capital maintenance, we propose to use 'menu' regulation. This replaces the traditional 'take it or appeal it' single regulatory offer with a menu of choices structured to encourage the company to choose a level of expenditure which best matches its expected outturn level of costs. We will publish our conclusions to this consultation in March 2008.

Currently, we monitor operating and capital relative efficiencies separately. We further divide capital efficiency between capital enhancement and capital maintenance expenditure. We do this mainly for simplicity. We use econometric and unit cost models to assess operating expenditure relative efficiency and capital maintenance relative efficiency each year. Every five years, we also use the cost base tool to assess capital unit cost relative efficiency. Since PR04, we have been working with stakeholders to develop our approach to the cost base. In [PR09/01](#) we consulted on draft cost base information requirements for the 2009 price review (PR09) and we published the [final information requirements](#) on 30 November 2007.

It is important for us to recognise the interaction between operating and capital expenditure and to appreciate that accounting policy can influence the outcome of individual areas of expenditure. Because of this interaction, we present operating and capital maintenance relative efficiency together.

We break both operating expenditure and capital maintenance expenditure into a number of smaller cost areas, and derive econometric models or unit cost models for each of these areas. In the diagram below, we have outlined the step-by-step approach we use to derive our econometric models. We have included more detail on the specific models used, including the form and coefficients, in chapter 4 of this supporting information.

Step-by-step approach to determining a model



Note:

* In practice, there are a number of iterations through steps 5, 6 and 7 as we develop and refine the models.

2.1 Operating expenditure models

For operating expenditure we assess relative efficiency separately for the water and sewerage services. We assess operating expenditure relative efficiency for the water service using four econometric models:

- water distribution;
- water resources and treatment;
- water power; and
- water business activities.

We assess operating expenditure relative efficiency for the sewerage service using two econometric models and three unit cost models. The econometric models are for:

- large sewage treatment works; and
- sewerage network including power.

The three operating expenditure sewerage service unit cost models are for:

- small sewage treatment works;
- sludge treatment and disposal; and
- sewerage business activities.

2.2 Capital maintenance expenditure models

We also assess capital maintenance relative expenditure separately for water and sewerage. For the water service we use three econometric models and one unit cost model. The econometric models are for:

- water distribution infrastructure;
- water distribution non-infrastructure; and
- water management and general.

The water capital maintenance unit cost model is for water resources and treatment.

We assess sewerage service capital maintenance relative efficiency using two econometric models and three unit cost models. The econometric models are for:

- sewerage infrastructure; and
- sewage treatment.

The three capital maintenance sewerage service unit cost models are for:

- sewerage non-infrastructure;
- sludge treatment and disposal; and
- sewerage management and general.

2.3 Calculating relative efficiency assessments

Companies submit detailed data for use in the water and sewerage service operating efficiency assessments in their June returns. The June returns also provide capital maintenance expenditure data annually, although we only collect detailed explanatory data every five years in the capital maintenance econometric return (CMER). For both operating expenditure and capital maintenance expenditure, we collect more detailed data for the sewerage service. This includes information for a number of areas within each company's region and data on individual large sewage treatment works and small sewage treatment works, split by size band. Although this is not as good as having truly independent data, collecting this sub-company information does allow us to assess relative efficiency for the sewerage service.

For our operating cost models we use a single year's expenditure data to estimate the models. This is because operating expenditure is less susceptible to significant variations year on year. In contrast, capital maintenance expenditure varies from year to year. In order to avoid relative efficiency assessments that fluctuate from one year to the next, we model average expenditure over a period of time. For the 2006-07 capital maintenance assessment we have used average expenditure over a seven-year period from 2000-01 to 2006-07. This reflects companies' current practices which have changed in recent years, in particular through the development of the common framework for planning capital maintenance. This period reflects one complete annual monitoring period, and the start of the current period.

For the operating expenditure models we use the current year's explanatory factor data. For the capital maintenance expenditure models we continue to use explanatory variables from 1997-98, as collected in the 2002 capital maintenance econometric return. These variables reflect a company's assets before the modelled expenditure period. We use data which reflects companies' assets before the period of modelled expenditure to make sure that the explanatory variables are independent of decisions taken during the period.

2.4 Pre-modelling adjustments

We make some adjustments to the companies' June return data before we estimate the econometric models. We make adjustments for:

- leakage allocations in the water operating cost distribution model;
- special factor adjustments directly attributable to water treatment, in the water operating cost resources and treatment model; and
- expenditure on quality driven mains renovation (section 19 undertakings) in the water capital maintenance distribution infrastructure model (WDI adjustment).

We explain these adjustments further in chapter 6 of this supporting information, and provide the values of the adjustments for this year's modelling in chapter 5.

2.5 Combining the results of the models

For the operating cost assessments we combine the results of the four water models, together with any adjustments for atypical costs, company-specific special factors and pension costs. We then assess each company's position relative to the benchmark company to give us an overall water service operating expenditure efficiency band. Similarly, we combine the results of the five sewerage models with any adjustments for atypical costs, special factors and pension costs. We then assess each company's position relative to the benchmark company to give an overall sewerage service operating efficiency band.

For the capital maintenance water assessment, we make adjustments for company-specific special factors and leakage allocations after we have combined the models. We then assess the distance of each company from the benchmark to give an overall water service capital maintenance efficiency band. For the sewerage service, we combine the results of the five models with any adjustments for company-specific special factors before we assess the distance of each company from the benchmark.

In both the operating expenditure and capital maintenance models, we have also reduced the modelling residuals (the difference between actual costs and the costs predicted by the models) to take some account of possible errors in the data and in our statistical process. We have adjusted the water residuals by 10% and the sewerage residuals by 20%.

More detail on the adjustments we make when combining the results of the models can be found in chapter 6 of this supporting information.

Determining the benchmark

We assess the benchmark company separately for each of the four cost areas:

- water operating expenditure;
- sewerage operating expenditure;
- water capital maintenance expenditure; and
- sewerage capital maintenance expenditure.

The benchmark company is not always the company at the efficiency frontier. It needs to satisfy a number of criteria, including size, to make it suitable for comparison with the rest of the industry. Our main criteria are summarised below.

- We must have no special concerns about the consistency of the data with our reporting requirements for the potential benchmark company.
- The potential benchmark company must have no special characteristics that are outside the control of management and which significantly reduce costs relative to the industry norm.
- The potential benchmark must represent a reasonable proportion of the industry. To date, our pragmatic threshold has been about 3% of the industry (by service turnover). A group of smaller companies that, when taken as a whole, are big enough to exceed the threshold, will be as suitable as one company with a turnover above 3%.
- For capital maintenance, a company must have stable or improving serviceability. This is so that we do not use a company whose capital maintenance practices have not been sufficient to deliver expected outputs.

Banding and ranking

After making the adjustments and determining the benchmark we then rank the companies in order of relative efficiency and divide them into five bands, where A is the most efficient. We band companies according to the percentage reductions they would need to make to costs in order to achieve the efficiency of our chosen benchmark company.

For operating expenditure we assess companies within 5% of the benchmark company as band A. Subsequent bands are at 10% intervals from the bottom of band A. Band A also includes companies that are more efficient than the benchmark company, but are not suitable for use as the benchmark company.

For capital maintenance expenditure we band companies at 10% intervals from the benchmark company. We also assess as band A companies that are more efficient than the benchmark, but do not fulfil our benchmark criteria. This approach differs from our approach to operating expenditure where we use a 5% band A. The

approach that we take on capital maintenance ensures that the capital maintenance bandings can be compared historically. This approach has been the same since the 1999 price review when the companies were more widely spread on capital maintenance.

We are keen to move away from the 10% band A approach for capital maintenance and use the same approach as for operating expenditure. We aim to do this as part of the development of the capital maintenance models for the next price review. This change would have no impact on the efficiency targets set for each company at PR09. If we adopted a 5% band A for our 2006-07 assessment, seven companies would be in a lower band for the water service. These companies are Anglian, Dŵr Cymru, Northumbrian, Southern, Bristol, South East, and Sutton & East Surrey. The choice of benchmark for the sewerage service means there would be no changes in bands if we moved to a 5% band A.

3. Progress on model development

3.1 Water operating cost distribution model

We have reviewed the distribution operating expenditure model with the industry during the last year, because of the deterioration of the current model. The previous model used proportion of large mains as the explanatory variable to describe the companies' operating environments. We used this variable as a proxy for urbanisation and assumed that it is more expensive to operate a distribution network in an urban area. The statistical validity of this variable has decreased over several years and because of this deterioration, we have reviewed several alternative models and also asked the industry for its views.

Following our review, and after taking advice from our econometric advisor, Professor Mark Stewart, we have concluded that we should replace the current distribution model with a model that includes a measure of density of connections. This is consistent with the view of the majority of water companies that density of connections is a cost driver. We have not yet finalised the new form of the model, so the results in RD21/07 are based on the old form of the model. We will write to companies early in 2008 to let them know the outcome of our review of the water distribution model.

3.2 Sewage sludge operating cost model

We are continuing to develop a sewage sludge econometric model. All ten water and sewerage companies provided sludge data for the 2005-06 report year and we were able to carry out initial testing of both unit cost and econometric models. We have worked with the industry to understand the key drivers of sludge costs and have had helpful visits to a number of companies. Our initial analysis allowed us to reduce slightly the amount of data collected for the 2006-07 report year. We were also able to clarify the guidance to ensure data was reported more consistently across companies.

We have received data from all companies for the 2006-07 report year. We are currently reviewing the data and will then test both unit cost and econometric models. We will share the results of the analysis with the industry in spring 2008. We hope that the work in this area will enable us to derive an appropriate model for assessing relative efficiency at PR09.

3.3 Review of capital maintenance econometric models and CMER

This year, we have carried out a full review of the capital maintenance econometric return (CMER). We will use this to collect explanatory factor data for 2002-03 to inform our capital maintenance econometric models for 2007-08 onwards. We consulted with the industry in [RD10/07](#) on suggested improvements to the models and changes to the explanatory factor data collected in the CMER. In July, we held discussions about the consultation responses at an industry workshop. We reviewed the comments and views of the industry and, where appropriate, we made changes to the draft version of the CMER in [RD17/07](#).

Using the responses from [RD17/07](#) and following further industry contact, we finalised the CMER and published it in [PR09/05](#). Each company will submit its completed CMER during February 2008. This set of explanatory factor data will give us the opportunity to review and develop new capital maintenance econometric models ahead of [PR09](#). We are currently consulting on our approach to setting price limits for 2010-15. Our preferred approach for capital maintenance expenditure is to use menu regulation. Adopting menu regulation would mean that we would no longer need to use the econometric models to assess the relative efficiency of companies for capital maintenance expenditure.

3.4 Special factors

In March 2006, a steering group comprising industry representatives and Ofwat, appointed consultants from Reckon to carry out a review of our approach to assessing efficiency. Reckon published its final report in March 2007 and included a number of recommendations for areas of possible development. One of the recommendations was to improve the special factor process, in particular by integrating the special factor adjustments into the efficiency modelling process and by making negative special factor adjustments.

We have taken this recommendation further and are currently considering whether any improvements could be made to the special factor process ahead of [PR09](#). We have carried out an initial review of integrating special factors into the modelling process and have taken advice from our econometric advisor, Professor Mark Stewart. We have a number of concerns about making the special factor adjustments before the econometric modelling is carried out. Some of these concerns are detailed below.

- In our current approach, we make special factor adjustments at the end of the process. Any inaccuracy in a company's claim only affects its own efficiency score. If the adjustments are made before the modelling is carried out then any inaccuracies in the claims will affect every company's score.
- In order to review all companies' special factor claims in time to include them at the pre-modelling stage, they would need to be submitted earlier than they are at the moment. Our initial view is that claims would need to be submitted with June returns and we would be less flexible about extensions to this deadline than we have been in previous years.
- Some special factors are easy to assign to a particular model. However, for others a judgement has to be made in order to split the costs across the models. This becomes more of an issue with the sewerage service, where special factor claims would need to be split across large works and sewerage sub-areas, as we collect data at a sub-company level in some areas.

We have not yet concluded our investigations into improving the special factor process. The application of special factors at the pre-modelling stage is only one area we are looking at. We are also considering introducing triviality and materiality thresholds for claims and we will be providing more detailed guidance to each company and to reporters. We will be writing to each company by spring 2008 with our conclusions of this review. This will provide detail of the special factor process that we intend to use for PR09. This will make it clear that each company will need to re-submit all special factor claims next year ahead of PR09, as no previously accepted claims will be carried forward.

3.5 Time series data

Another of the recommendations included in Reckon's report on the review of our approach to efficiency was related to time series data. The recommendation was that we should make better use of the historical data available to us. As a result of this, another project steering group was set up comprising representatives from Ofwat, UK Water Industry Research (UKWIR) and the industry. In July 2007, the group appointed consultants Reckon to carry out a further study to look at the use of time series data in assessing relative efficiency. The findings of this project are due to be published in December 2007.

Early indications suggest that Reckon will make the following recommendations.

- Time series modelling should be used for water operating expenditure.
- Time series modelling should be used for sewerage business activities expenditure where we currently use a company level model.

- Time series models should be considered for the other sewerage models where we currently use sub-company data.
- Time series models should be used to provide an estimate of the extent to which companies have tended to catch-up differences in the past and differences between companies' expenditure which have persisted over time.

We will review the final report when it is published, and will take into account its findings in our analysis for PR09.

4. Relative efficiency models

To assess relative efficiency, we break both operating expenditure and capital maintenance expenditure into a number of smaller cost areas, and derive econometric models or unit cost models for each of these areas. A breakdown of the costs included in each of these areas can be found in the [regulatory accounting guidelines](#). We provide further detail on each of our econometric models below. We have outlined our approach to measuring relative efficiency and the step-by-step approach we use to derive our econometric models in chapter 2 of this supporting information.

4.1 Water operating expenditure models

We assess operating expenditure relative efficiency for the water service using four econometric models. The form and coefficients of the models are set out later in this section.

Water distribution

This is a log model expressed in unit cost form with resident winter population as the scale variable. The proportion of large mains to small mains is the cost driver in this model. We use this as a proxy for urbanisation. Repairs, maintenance and inspection of large mains incur much greater costs than the same work on small mains. We are currently reviewing this model. We have provided information on our progress in section 3.1.

Water resources and treatment

This is a linear model expressed in unit cost form with resident winter population as the scale variable. Last year, we made a change to one of the variables in the model. We now include the proportion of supplies from boreholes, instead of the proportion of supplies from rivers. We also take into account the explanatory variables of number of sources and distribution input. These variables ensure that we take into account economies of scale at source level (costs will be lower if fewer sources are used) and the difficulty of treatment (borehole supplies will generally be cheaper to treat).

Water power

This is a log linear model. For most companies, power expenditure is almost entirely for pumping, although there are some water treatment processes that use a lot of energy. The model considers the effects of terrain (companies in hilly areas will require more power to move water around) and the significant economies of scale

associated with high power consumption. The cost drivers in this model are average pumping head and distribution input.

Water business activities

This is a log linear model. Business activities include customer services and scientific services, and the charge for doubtful debts. The cost driver is the number of billed properties. The model takes into account the economies of scale associated with high volume billing and customer service activities.

4.2 Sewerage operating expenditure models

Three of the operating expenditure models for the sewerage service are unit cost models for:

- small sewage treatment works (and sea outfalls);
- sludge treatment and disposal; and
- business activities.

The remaining two operating expenditure econometric models for the sewerage service are set out below.

Network including power

This is a log linear model expressed in unit cost form with the total length of sewer as the scale variable. The explanatory variables used in the network model are:

- sewer length;
- area of sewer district;
- resident population; and
- holiday population.

In simple terms, the model takes account of the density of the sewerage network and the population it serves, and the higher costs associated with the sewer capacity required to serve additional summer populations.

Large sewage treatment works

This is a log linear model. It uses a number of explanatory variables that take account of the total load, the type of treatment used, and the nature of effluent consents. These explanatory variables affect costs (it is more expensive to meet tight effluent consents, for example).

4.3 Water capital maintenance expenditure models

The capital maintenance assessment consists of one unit cost comparison (water resources and treatment) and three econometric models, which are set out below.

Water distribution infrastructure

This is a log unit cost model expressed in unit cost form with length of main as the scale variable. The key cost driver in this model is the log of connected properties divided by the total length of main.

Water distribution non-infrastructure

This is a log unit cost model expressed in unit cost form with total booster pumping station capacity as the scale variable. We take into account water tower and service reservoir capacities in this model. The ratio of storage capacity to pumping station capacity helps to explain the higher costs of companies with relatively greater storage capacity.

Water management and general

This is a log model expressed in unit cost form with the total number of billed properties as the scale variable. The key cost driver in this model is the proportion of non-household billed properties. The model explains the higher unit costs that companies with more business customers incur because of metering and billing requirements.

4.4 Sewerage capital maintenance expenditure models

For capital maintenance expenditure, we assess the sewerage service using unit cost models for:

- sewerage non-infrastructure;
- sludge treatment and disposal; and
- management and general.

The remaining two econometric models are set out below.

Sewage treatment

This is a log unit cost model with the total load treated by works as the scale variable. The explanatory factor in this model is the load treated at each sewage treatment works. Economies of scale at the works level are taken into account, because fewer larger works will be less costly to maintain, as are the higher costs associated with post-primary levels of treatment.

Sewerage infrastructure

This is a log unit cost model with the total length of sewers as the scale variable. The number of combined sewer overflows is the key cost driver in this model. It is an indicator of the extent of combined sewers in the network. Combined sewers are generally larger and more costly to replace than foul sewers. This cost driver therefore helps to explain the higher maintenance costs that companies with a greater number of combined sewer overflows incur.

4.5 Definition of the terms and abbreviations in the econometric model descriptions

We have used the following terms and abbreviations in the following tables.

Model significance (F test): We use this to determine whether there is an association between the modelled cost and the other variables used in a model. The number in our tables is the probability that there is no association between the variables. Therefore, a small number (we usually say less than 0.05) means that there is a statistically significant association between the variables.

R²: This shows how closely the variables in the model are related to each other. It lies between 0 and 1; an R² of 1 means there is a perfect linear relationship and an R² of 0 means there is no linear relationship. However, the R² value can be misleading if used on its own. Other statistics should be considered as well to assess how well a model performs.

Model standard error: This is a measure of the overall variation in a model. It measures how spread out the data is around the regression line. The further away the data points are from the regression line the greater the value of the standard error. It is based on the standard deviation of the data points – the smaller the number relative to the mean of the data the better the fit of the regression line.

ln: The logarithm to base e, also called the natural logarithm.

BOD₅: Five-day biochemical oxygen demand (BOD₅) is a standard way of measuring the polluting effect of wastewater. It is a measure of how much oxygen is consumed in five days at a temperature of 20°C by any micro-organisms or organic matter present in the water.

COD: Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrate. COD measurements are

commonly made on samples of wastewaters or natural waters contaminated by domestic or industrial waste.

Operating expenditure – water distribution model

Water service:	Distribution expenditure	
Data:	June returns 2007	
Modelled cost:	In (distribution functional expenditure excluding power expenditure [£m], divided by resident winter population [000s])	
Explanatory variables:	Coefficient	Standard error
Constant	-5.087	0.194
Length of main greater than 320 mm diameter [km], divided by total length of main [km]	4.048	2.432
Form of model:	Modelled cost = $-5.087 + 4.048 \times \frac{\text{length of main} > 320 \text{ mm diameter}}{\text{total length of main}}$	
Statistical indicators:	Number of observations: 22	R ² : 0.122
	Model standard error: 0.269	Model significant (F test): 0.112

Operating expenditure – water resources and treatment model

Water service:	Resources and treatment expenditure	
Data:	June returns 2007	
Modelled cost:	Resources and treatment functional expenditure [£m], less power expenditure [£m], less service charges [£m], divided by resident winter population [millions]	
Explanatory variables:	Coefficient	Standard error
Constant	5.818	1.054
Number of sources divided by distribution input [M/day]	20.268	8.153
Proportion of supplies derived from boreholes	-4.807	2.419
Form of model:	Modelled cost = $5.818 + 20.268 \times \frac{\text{number of sources}}{\text{distribution input}} - 4.807 \times (\text{proportion of supply from boreholes})$	
Statistical indicators:	Number of observations: 22	R ² : 0.246
	Model standard error: 2.432	Model significant (F test): 0.069

Operating expenditure – water power model

Water service:	Power expenditure	
Data:	June returns 2007	
Modelled cost:	In power expenditure [£m]	
Explanatory variables:	Coefficient	Standard error
Constant	-8.562	0.349
In (distribution input – DI – [M/day], multiplied by average pumping head)	0.954	0.032
Form of model:	Modelled cost = $-8.562 + 0.954 \times \ln(\text{DI} \times \text{average pumping head})$	
Statistical indicators:	Number of observations: 22	R ² : 0.978
	Model standard error: 0.201	Model significant (F test): 0.000

Operating expenditure – water business activities model

Water service:	Business activities expenditure	
Data:	June returns 2007	
Modelled cost:	ln (business activities expenditure [£m] including doubtful debts [£m])	
Explanatory variables:	Coefficient	Standard error
Constant	-3.616	0.245
ln of number of billed properties [000s]	0.922	0.038
Form of model:	Modelled cost = $-3.616 + 0.922 \times \ln(\text{number of billed properties})$	
Statistical indicators:	Number of observations: 22	R ² : 0.967
	Model standard error: 0.213	Model significant (F test): 0.000

Operating expenditure – sewerage network (including power) model

Sewerage service:	Sewerage network expenditure	
Data:	June returns 2007	
Modelled cost:	ln (sewerage network functional expenditure [£m], plus terminal pumping costs, less service charges [£m], per kilometre of sewer, for each area)	
Explanatory variables:	Coefficient	Standard error
Constant	-6.027	0.452
ln (area sewer district [km ²] per kilometre of sewer)	0.162	0.040
ln (resident population [000s] per kilometre of sewer)	0.508	0.235
Holiday population divided by resident population [000s]	1.546	1.225
Form of model:	Modelled cost = -6.027 $+ 0.162 \times \ln(\text{area of sewer district per km of sewer})$ $+ 0.508 \times \ln(\text{resident population per km of sewer})$ $+ 1.546 \times \frac{\text{holiday population}}{\text{resident population}}$	
Statistical indicators:	Number of observations: 59	R ² : 0.310
	Model standard error: 0.269	Model significant (F test): 0.000

Operating expenditure – large sewage treatment works model

Sewerage service:	Cost of sewage treatment at large works	
Data:	June returns 2007	
Modelled cost:	In (functional expenditure on sewage treatment at large works [£000s], less service charges [£000s], less terminal pumping costs [£000s])	
Explanatory variables:	Coefficient	Standard error
Constant	-1.289	0.248
In of total load [kg COD/day] ¹	0.769	0.028
Activated sludge ²	0.423	0.052
Tight effluent consent for both suspended solids and BOD ₅ ³	0.158	0.047
Form of model:	Modelled cost = $-1.289 + 0.769 \times \text{In (total load)}$ $+ 0.423 \times \text{activated sludge}$ $+ 0.158 \times \text{tight effluent consent for both suspended solids and BOD}_5$	
Statistical indicators:	Number of observations: 385	R ² : 0.733
	Model standard error: 0.458	Model significant (F test): 0.000

Notes:

- Total load in this model is estimated as population equivalent x 120.
- Activated sludge includes secondary and tertiary treatment. Variable value is 0 if not used, 1 if used.
- The tight effluent consent is based on the levels of suspended solids (mg/l) and BOD₅ (mg/l) and on the ammonia levels (mg/l). Variable value is 0 if tight consent does not apply and 1 if the tight consent does apply.

Operating expenditure – small sewage treatment works unit cost model

Sewerage service:	Cost of sewage treatment at small works									
Data:	June returns 2007									
Unit cost model:	We used a unit cost approach for modelling sewage treatment at small works, using ten treatment categories and five size bands. For each treatment type we compared each company's average annual expenditure (direct costs [£000s], less service charges [£000s], plus general and support costs [£000s]) with each company's estimated expenditure (weighted average industry unit cost multiplied by each company's load [kg BOD ₅ /day]).									
Weighted average industry unit cost £000s/(kg BOD ₅ /day)										
Treatment type	Primary	Secondary activated sludge	Secondary biological	Tertiary A1	Tertiary A2	Tertiary B1	Tertiary B2	Sea outfall preliminary	Sea outfall screened	Sea outfall unscreened
Size band 1	0.73	1.18	1.07	1.27	0.54	1.13	0.86	0.72	0.00	0.30
Size band 2	0.17	0.83	0.52	0.92	0.74	0.61	0.50	0.00	0.00	0.00
Size band 3	0.22	0.51	0.36	0.56	0.50	0.39	0.42	0.04	0.10	0.03
Size band 4	0.35	0.30	0.19	0.25	0.36	0.19	0.21	0.00	0.33	0.00
Size band 5	0.00	0.22	0.12	0.19	0.20	0.13	0.14	0.03	0.00	0.00
Number of observations:	500									

Operating expenditure – sludge treatment and disposal unit cost model

Sewerage service:		Cost of sludge treatment and disposal						
Data:		June returns 2007						
Unit cost model:		<p>We used a unit cost approach for modelling the treatment and disposal of sludge.</p> <p>For each disposal route, we compared each company's average annual expenditure (sludge functional expenditure [£000s], less service charges [£000s]) with each company's estimated costs (weighted average industry unit cost multiplied by each company's load [ttds]).</p>						
Weighted average industry unit cost £000s/(thousand tonnes of dry solids)								
Disposal route	Farmland (untreated)	Farmland (conventional)	Farmland (advanced)	Incineration	Landfill	Composted	Land reclamation	Other
£000s/ttds	0	174.3	192.7	210.2	178.6	272.6	136.7	236.9
Number of observations:		80						

Operating expenditure – sewerage business activities unit cost model

Sewerage service:		Sewerage business activities expenditure	
Data:		June returns 2007	
Unit cost model:		<p>We used a unit cost approach for modelling business activities, based on the number of billed properties.</p> <p>We compared each company's average annual business activities expenditure (total business activities [£m], plus doubtful debts [£m], divided by the number of billed properties) with the weighted average industry cost.</p>	
£/billed property		Weighted average industry unit cost 13.05	
Number of observations:		10	

Capital maintenance expenditure – water distribution infrastructure model

Water service:	Water distribution infrastructure expenditure	
Data:	Capital maintenance econometric return, June returns 2000-07	
Modelled cost:	ln (annual average water distribution infrastructure functional expenditure [£m], divided by length of main [km])	
Explanatory variables:	Coefficient	Standard error
Constant	-4.785	0.706
ln (total number of connected properties [000s], divided by total length of main [km])	0.821	0.261
Form of model:	$\text{Modelled cost} = -4.785 + 0.821 \times \ln \left\{ \frac{\text{no. of connected properties}}{\text{total length of main}} \right\}$	
Statistical indicators:	Number of observations: 22	R ² : 0.331
	Model standard error: 0.277	Model significance (F test): 0.005

Capital maintenance expenditure – water distribution non-infrastructure model

Water service:	Water distribution non-infrastructure expenditure	
Data:	Capital maintenance econometric return, June returns 2000-07	
Modelled cost:	ln (annual average water distribution non-infrastructure functional expenditure [£m], divided by pumping station capacity [kW])	
Explanatory variables:	Coefficient	Standard error
Constant	-5.793	0.522
ln (water service reservoir and water tower storage capacity [MI/d], divided by pumping station capacity [kW])	0.886	0.203
Form of model:	$\text{ln modelled cost} = -5.793 + 0.886 \times \ln \left\{ \frac{\text{storage capacity}}{\text{pumping station capacity}} \right\}$	
Statistical indicators:	Number of observations: 22	R ² : 0.487
	Model standard error: 0.558	Model significance (F test): 0.000

Capital maintenance expenditure – water management and general model

Water service:	Water management and general expenditure	
Data:	Capital maintenance econometric return, June returns 2000-07	
Modelled cost:	ln (annual average management and general expenditure [£m], divided by billed properties [000s])	
Explanatory variables:	Coefficient	Standard error
Constant	-5.463	0.246
Proportion of billed non-household properties	8.580	3.211
Form of model:	$\text{Modelled cost} = -5.463 + 8.580 \times \text{proportion of non-household properties}$	
Statistical indicators:	Number of observations: 21	R ² : 0.273
	Model standard error: 0.202	Model significance (F test): 0.015

Capital maintenance expenditure – water resources and treatment model

Water service:	Water resources and treatment expenditure
Data:	Capital maintenance econometric return, June returns 2000-07
Unit cost model:	We used a unit cost approach for the water resource and treatment model. We divided each company's average annual expenditure by the total connected properties and compared this with the weighted average industry cost.
£/connected properties	Weighted average industry cost 10.013
Number of observations:	22

Capital maintenance expenditure – sewerage infrastructure model

Sewerage service:	Sewerage infrastructure expenditure	
Data:	Capital maintenance econometric return, June returns 2000-2007	
Modelled cost:	ln (average annual sewerage infrastructure expenditure [£m], divided by the total length of sewer [km])	
Explanatory variables:	Coefficient	Standard error
Constant	-6.187	0.182
ln (the number of combined sewer overflows – CSOs – divided by the total length of sewer [km])	0.341	0.052
Form of model:	Modelled cost = $-6.187 + 0.341 \times \ln \left\{ \frac{\text{number of CSOs}}{\text{total length of sewer}} \right\}$	
Statistical indicators:	Number of observations: 62	R ² : 0.414
	Model standard error: 0.406	Model significance (F test): 0.000

Capital maintenance expenditure – sewage treatment model

Sewerage service:	Sewage treatment expenditure	
Data:	Capital maintenance econometric return, June returns 2000-07	
Modelled cost:	ln (average annual sewage treatment functional expenditure [£m], divided by the total load received at sewage treatment works [kg BOD ₅ /day])	
Explanatory variables:	Coefficient	Standard error
Constant	-7.905	0.278
ln (the total number of works, divided by total load received at sewage treatment works [kg BOD ₅ /day])	0.180	0.041
Form of model:	Modelled cost = $-7.905 + 0.180 \times \ln \left\{ \frac{\text{total number of works}}{\text{total load received at works}} \right\}$	
Statistical indicators:	Number of observations: 59	R ² : 0.249
	Model standard error: 0.472	Model significance (F test): 0.000

Capital maintenance expenditure – sewerage non-infrastructure model

Sewerage service:	Sewerage non-infrastructure expenditure
Data:	Capital maintenance econometric return, June returns 2000-07
Unit cost model:	A unit cost approach resulted from modelling sewerage non-infrastructure data. We compared each company's average annual expenditure [£m], divided by the total number of pumping stations with the weighted average industry cost.
£m/number of pumping stations [000s]:	Weighted average industry cost 3.783
Number of observations:	10

Capital maintenance expenditure – sludge treatment and disposal model

Sewerage service:	Sludge treatment and disposal expenditure
Data:	Capital maintenance econometric return, June returns 2000-07
Unit cost model:	We used a unit cost approach for the sludge treatment and disposal model. We compared each company's average annual sludge expenditure [£000s], divided by the total weight of dry solids disposed of [ttds] with the weighted average industry cost.
£000s/thousand tonnes of dry solids:	Weighted average industry cost 81.659
Number of observations:	10

Capital maintenance expenditure – sewerage management and general model

Sewerage service:	Sewerage management and general expenditure
Data:	Capital maintenance econometric return, June returns 2000-07
Unit cost model:	We adopted a unit cost approach for sewerage management and general expenditure, comparing each company's average annual expenditure [£m] per billed property [millions] with the weighted average industry cost.
£/billed property:	Weighted average industry cost 7.196
Number of observations:	10

5. Model data

The June return data and other adjustments made to the data before it is used in the relative efficiency modelling can be found at the following links:

- [water operating expenditure model data](#);
- [sewerage operating expenditure model data](#);
- [water capital maintenance expenditure model data](#); and
- [sewerage capital maintenance expenditure model data](#).

6. Adjustments made to the data used in the relative efficiency models

We make a number of adjustments to the June return data that companies submitted to us. We explain these adjustments in more detail below. The value of each of the adjustments for each company for 2006-07 can be found in chapter 5.

6.1 Leakage adjustment

For the water service, we make adjustments to some companies' costs so that we can be sure that the data we use to assess relative efficiency is reported consistently across companies. We move some leakage control costs to operating expenditure from capital maintenance expenditure. We make these adjustments to distribution operating expenditure and to total capital maintenance expenditure. Since 2005-06, we have needed to make adjustments for fewer companies as some companies moved leakage control costs from capital maintenance to operating expenditure in line with our assumptions at the 2004 price review. However, since we base our adjustments for capital maintenance on average leakage expenditure re-allocations over the period being modelled, we make more adjustments for capital maintenance expenditure than for operating expenditure.

6.2 Water distribution infrastructure (WDI) adjustment

We adjust capital maintenance water distribution infrastructure expenditure to take account of companies' different allocation policies for section 19 undertaking (S19) expenditure. S19 is a quality driven mains renovation programme which started in 1989 to improve the colour and appearance of water at customers' taps. Some companies proportionally allocate expenditure on S19 between quality and maintenance. Other companies allocate all S19 expenditure to quality, and others allocate all S19 expenditure to maintenance. The WDI adjustment creates a level playing field in order to model accurately the relative costs of distribution infrastructure activity. Most companies have now completed the programme, although as we use a seven year average of expenditure for the capital maintenance models we still have a number of companies with this adjustment. The value of these adjustments for 2006-07 can be found with the model data in chapter 5.

6.3 Pension adjustment

We make adjustments to operating expenditure for some companies for pensions. We make these adjustments when we combine the models. We need to make the pension adjustments following the introduction of a new accounting standard for pensions, FRS 17, which replaced SSAP 24. Because a small number of companies legitimately use the permitted multi-employer exemption from FRS 17 requirements on accounting for pension deficit recovery, we have to make some adjustments to create a level playing field for assessing relative efficiency. We have therefore made adjustments for the small number of companies that have used the multi-employer exemption. In addition, FRS17 appears to introduce a distortion to reported operating expenditure where a company is on a pension holiday but has high future liabilities. We have also made an adjustment to take account of this when assessing the relative efficiency of one company.

6.4 Atypical operating costs

Our operating expenditure efficiency models assess the efficiency of a water company performing its duties in a typical year. We do not want the assessment to be distorted by unusual one-off costs. Each company therefore reports and identifies atypical operating costs that are not part of the continuing operation of the business. A company could include:

- provisions for restructuring;
- extreme climatic events;
- costs associated with takeover bids or bid defence;
- compensation payments to customers; and
- abnormal changes in pension contributions.

Some companies declare these and similar items as 'exceptional items' in their accounts and we do not include them in our econometric modelling. Other companies report them within normal costs. When a company reports them as part of their normal costs, we make an adjustment to exclude them from our modelling. Since costs associated with providing services to third parties, local authority rates, Environment Agency and British Waterways costs are not included in our relative efficiency modelling, we do not adjust for atypical levels of these costs in our econometric modelling. We make the adjustments for atypical costs when we combine the results of the models.

6.5 Special factors

The econometric models take into account factors that describe the size or operating environment of different companies. However, there are some factors that are specific to each company or a group of companies that we cannot incorporate into our econometric models. Such company-specific special factors typically lead to higher operating or capital maintenance costs, which in the short to medium term are outside management control. We need to take account of these when we interpret the results of our econometric models. We call these adjustments special factors. Special factors can include legal requirements or circumstances peculiar to an individual company's area of operation.

In the run-up to the 2004 price review we asked companies to submit claims for special factors to include in our relative efficiency assessments. We asked companies to provide us with information about each claim based on the four criteria listed below.

- What is different about the circumstances that cause materially higher costs?
- Why do these circumstances lead to materially higher costs?
- What is the net impact of these costs on prices? What has been done to manage the additional costs arising from the different circumstances and to limit their impact?
- Are there any other different circumstances that reduce the company's costs relative to the industry norms?

This year, for companies that did not submit updated claims, we have rolled forward the special factor adjustments included in last year's assessment. For capital maintenance we revised these allowances to reflect the seven-year period of expenditure we have modelled. A number of companies submitted new claims for 2006-07. We have reviewed these claims and made some allowances in our assessment. We apply special factors for operating expenditure when the models are combined and for capital maintenance we make the adjustments after the adjustment for leakage allocation.

Ahead of PR09, we will be asking companies to re-submit all of their special factor claims. We will write to all companies early in 2008 providing detail on the timetable for the special factor process, as well as giving clear guidance to both companies and reporters on the criteria for special factor claims.